U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: EXTENDED RANGE OPERATION WITH TWO-ENGINE AIRPLANES (ETOPS)

Date: 12/30/88
Initiated by: AFS-210/ ANM-270

AC No: 120-42A
Change:

1. PURPOSE. This advisory circular (AC) states an acceptable means, but not the only means, for obtaining approval under FAR Section 121.161 for two-engine airplanes to operate over a route that contains a point farther than one hour flying time at the normal one-engine inoperative cruise speed (in still air) from an adequate airport. Specific criteria are included for deviation of 75 minutes, 120 minutes or 180 minutes from an adequate airport.

2. CANCELLATION. AC 120-42, Extended Range Operation With Two-Engine Airplanes, dated June 6, 1985, is canceled.

3. RELATED FAR SECTIONS. Sections 21.3, 25.901, 25.903, 25.1309, 33.19, 33.75, 121.161, 121.197, 121.373, 121.565, and 121.703 of the Federal Aviation Regulations (FAR).

4. DEFINITIONS.

a. Airport.

(1) Adequate. For the purpose of this AC, an adequate airport is an airport certified as an FAR Part 139 airport or is found to be equivalent to FAR Part 139 safety requirements.

(2) Suitable. For the purpose of this AC, a suitable airport is an adequate airport with weather reports, or forecasts, or any combination thereof, indicating that the weather conditions are at or above operating minima, as specified in the operation specifications, and the field condition reports indicate that a safe landing can be accomplished at the time of the intended operation.

b. Auxiliary Power Units (APU). A gas turbine engine intended for use as a power source for driving generators, hydraulic pumps, and other airplane accessories and equipment and/or to provide compressed air for airplane pneumatic systems.

(1) An essential APU installation provides the bleed air and/or mechanical power necessary for the dispatch of a transport category airplane for operations other than extended range operations with two-engine airplanes.

(2) An APU installation which is intended to serve as one of the three or more independent alternating current (AC) electrical power sources required for extended range operations provides the bleed air or mechanical power necessary for the safe flight of a two-engine transport category airplane approved for extended range operation under a deviation from FAR Section 121.161 and is designed and maintained to provide a level of reliability necessary to perform its intended function.

c. ETOPS Configuration Maintenance and Procedures (CMP) Standard. The particular airplane configuration minimum requirements including any special inspection, hardware life limits, Master Minimum Equipment List (MMEL) constraints, and maintenance practices found necessary by the FAA to establish the suitability of an airframe-engine combination for extended range operation.

d. Engine. The basic engine assembly as supplied by the engine manufacturer.

e. Extended Range Operations. For the purpose of this AC, extended range operations are those flights conducted over a route that contain a point further than one hour flying time at the approved one-engine inoperative cruise speed (under standard conditions in still air) from an adequate airport.

f. Extended Range Entry Point. The extended range entry point is the point on the aircraft's outbound route which is one-hour flying time at the approved single-engine inoperative cruise speed (under standard conditions in still air) from an adequate airport.

g. Fail-Safe. A design methodology upon which the FAR Part 25 airworthiness standards are based. It requires the effect of failures and combination of failures to be considered in defining a safe design. (Refer to Appendix 2 for a more complete definition of fail-safe design concepts.)

h. In-flight Shutdown (IFSD). When an engine ceases to function in flight and is shutdown, whether self-induced, crew initiated or caused by some other external influence (i.e., IFSD for all causes; for example: due to flameout, internal failure, crew-initiated shutoff, foreign object ingestion, icing, inability to obtain and/or control desired thrust, etc.).

i. System. A system includes all elements of equipment necessary for the control and performance of a particular major function. It includes both the equipment specifically provided for the function in question and other basic equipment such as that necessary to supply power for the equipment operation.

(1) Airframe System. Any system on the airplane that is not a part of the propulsion system.

(2) Propulsion System. The airplane propulsion system includes: each component that is necessary for propulsion; components that effect the control of the major propulsion units; and components that effect the safe operation of the major propulsion units.

5. DISCUSSION. To be eligible for extended range operations, the specified airframe-engine combination should have been certificated to the airworthiness standards of transport category airplanes and should be evaluated considering the concepts in Paragraph 7, evaluated considering the type design considerations in Paragraph 8, evaluated considering in-service experience discussed in Paragraph 9, and evaluated considering the continuing airworthiness and operational concepts outlined in Paragraph 10.

a. General. All two-engine airplanes operated under Part 121 are required to comply with FAR 121.161. Section 121.161 states, (in pertinent part), that "unless otherwise authorized by the Administrator, based on the character of the terrain, the kind of operation, or the performance of the airplane to be used, no certificate holder may operate two-engine or three-engine airplanes (except a three-engine turbine powered airplane) over a route that contains a point farther than one hour flying time (in still air at normal cruising speed with one-engine inoperative) from an adequate airport." It is significant to note that this rule is applicable to reciprocating, turbopropeller, turbojet, and turbofan airplanes transiting oceanic areas or routes entirely over land.

b. Background. Although FAR 121.161 requirements evolved during the era of piston-engine airplanes and these requirements are currently applied to turbine-powered airplanes which have significantly better reliability, experience has shown the present rule to be effective and yet flexible enough in its application to accommodate significant improvements in technology. Until recently, little consideration had been given to reexamining the viability of extending the permissible operating range of two-engine turbine powered airplanes, by granting credit for improved reliability due to the limited range/payload capabilities of most of the existing generation of two-engine turbine-powered airplanes. However, some of the new generation airplanes have a range/payload capability equivalent to many previous generation three- and four-engine airplanes. The demonstrated range/payload capabilities of the new generation airplanes, including their provisions for achieving a higher degree of reliability, clearly indicate there is a need to recognize the capabilities of these airplanes and to establish the conditions under which extended range operations with these airplanes can be safely conducted over oceanic and/or desolate land areas.

c. 121.161 Historical Basis. FAR Section 121.161 has an extensive historical basis which began as early as 1936. The rule in effect in 1936 required the applicant to show, prior to obtaining approval for the operation, that intermediate fields, available for safe takeoff and landings, were located at least at 100 mile intervals along the proposed route. This restriction applied to all airplanes operating under this rule regardless of the terrain or area overflown. Throughout the evolution of the current 121.161 the following factors have remained constant:

(1) The rule has always applied to all areas of operation and has not been limited to overwater operation.

(2) Any additional restrictions imposed or, alternatively, any deviations granted to operate in excess of the basic requirements were based on a finding by the Administrator that adequate safety would be provided in the proposed operation when all factors were considered. This finding was never limited to engine reliability alone.

(3) The airports used in meeting the provisions of the rule must be adequate for the airplane used (i.e., available for safe landings and takeoff with the weights authorized), and

(4) In granting a deviation from the time restriction, the Administrator considers the character of the terrain, the kind of operation and the performance of the aircraft, etc.

6. APPLICABILITY. Since large transport category airplanes are certificated in consideration of the operating rule, FAR Section 121.161, any consideration for deviation from this operating rule for two-engine airplanes necessitates an evaluation of the type design to determine suitability of that particular airframe-engine combination for the intended operation. This circular provides guidance for obtaining type design, continued airworthiness and operations approval for those two-engine transport category airplanes intended for use in extended range operations. The issuance of this AC is not intended to alter the status of deviations previously approved in accordance with FAR Section 121.161. Although many of the criteria in this AC may be currently incorporated into an operator's approved program for other airplanes or route structures, the unique nature of extended range operations with two-engine airplanes necessitates an evaluation of these operations to ensure that the approved programs are effective. To the extent that changes in the airplane's type design, continued airworthiness, or the operations program are involved as a result of this evaluation, they are approved through the normal approval processes.

7. CONCEPTS. Although it is self-evident that the overall safety of an extended range operation cannot be better than that provided by the reliability of the propulsion systems, some of the factors

related to extended range operations are not necessarily obvious. For example, cargo compartment fire suppression/containment capability could be a significant factor or operational/maintenance practices may invalidate certain determinations made during the airplane type design certification, or the probability of system failures could be a more significant problem than the probability of propulsion system failures. Although engine reliability is a critical factor, it is not the only factor which should be seriously considered in evaluating extended range operations. Any decision relating to extended range operation with two-engine airplanes should also consider the probability of occurrence of any condition which would reduce the capability of the airplane or the ability of the crew to cope with adverse operating conditions. The following is provided to define the concepts for evaluating extended range operations with two-engine airplanes. This approach ensures that two-engine airplanes are consistent with the level of safety required for current extended range operations with three and four-engine turbine powered airplanes without unnecessarily restricting operation.

a. Airframe System. A number of airframe systems have an effect on the safety of extended range operations; therefore, the type design certification of the airplane should be reviewed to ensure that the design of these systems are acceptable for the safe conduct of the intended operation.

b. Propulsion System. A review of the historical data (1978 through 1988) for transport aviation two-engine turbofan powered large commercial airplanes indicates that the current safety record, as exemplified by the world accident rate (airworthiness causes), is sustained in part by a propulsion system IFSD rate of only about .02/1000 hours. Although the quality of this safety record is not wholly attributable to the IFSD rate, it is believed that maintaining an IFSD rate of that order is necessary to not adversely impact the world accident rate from airworthiness causes. Upon further review of the historical data base and in consideration of the required safety of extended range operation, it is necessary that the achieved performance and reliability of the airplane should be shown to be sufficiently high. When considering the impact of increasing diversion time, it must be shown that the operation can be conducted at a level of reliability resulting in no adverse change in risk.

c. Maintenance Reliability Program Definition. Since the quality of maintenance and reliability programs can have an appreciable effect on the reliability of the propulsion system and the airframe systems required for extended range operation, an assessment should be made of the proposed maintenance and reliability program's ability to maintain a satisfactory level of airplane systems reliability for the particular airframe-engine combination.

d. Maintenance and Reliability Program Implementation. Following a determination that the airframe systems and propulsion systems are designed to be suitable for extended range operations, an indepth review of the applicant's training programs, operations, and maintenance and reliability programs should be accomplished to show ability to achieve and maintain an acceptable level of systems reliability to safely conduct these operations.

e. Human Factors. System failures or malfunctions occurring during extended range operations could affect flightcrew workload and procedures. Although the demands on the flightcrew may increase, an assessment should be made to ensure that exceptional piloting skills or crew coordination are not required.

f. Approval Basis. Each applicant (manufacturer or operator as appropriate) for extended range approval should show that the particular airframe-engine combination is sufficiently reliable. Systems required for extended range operations should be shown by the manufacturer to be designed to a fail-safe criteria and should be shown by the operator to be continuously maintained and operated at levels of reliability appropriate for the intended operation.

(1) Type Design ETOPS Approval. Preceding the type design approval, the applicant should show that the airframe and propulsion systems for the particular airplane can achieve a sufficiently high level of reliability in service so that safe extended range operations may be conducted. The achievement of the required level of propulsion system reliability is determined in accordance with Appendix 1. (See Paragraph 9.a.) Evidence that the type design of the airplane is suitable for extended range operations is normally reflected by a statement in the FAA-approved Airplane Flight Manual (AFM) and Type Certificate Data sheet or Supplemental Type Certificate (See Paragraph 8.), which specifies the CMP standard requirements for suitability.

(2) Inservice Experience. It is also necessary for each operator desiring approval for extended range operations to show that it has obtained sufficient maintenance and operations experience with that particular airframe-engine combination to safely conduct these operations. (See Paragraph 9.b.)

(3) Operations Approval. The type design approval does not reflect a continuing airworthiness or operational approval to conduct extended range operations. Therefore, before approval, each operator should demonstrate the ability to maintain and operate the airplane so as to achieve the necessary reliability and to train its personnel to achieve competence in extended range operations. The operational approval to conduct extended range operations is made by amendment to the operator's operations specifications (see Paragraph 10) which includes requisite items provided in the AFM.

(4) Continuing Airworthiness. From time to time, the FAA may require that the type design CMP standard be revised to correct subsequent problems that impede the achievement of the required level of reliability. The FAA will initiate action as necessary to require a CMP standard revision to achieve and maintain desired level of reliability and, therefore, safety of the extended range operation. CMP standards in effect prior to revision will no longer be considered suitable for continued extended range operation.

8. TYPE DESIGN APPROVAL CONSIDERATION. When a two-engine type design airplane is intended to be used in extended range operations, a determination should be made that the design features are suitable for the intended operation. In some cases modifications to systems may be necessary to achieve the desired reliability. The essential airframe systems and the propulsion system for the particular airframe-engine combination should be shown to be designed to a fail-safe criteria and through service experience it must be determined that it can achieve a level of reliability suitable for the intended operation.

a. Request for Approval. An airplane manufacturer or other civil airworthiness authorities requesting a determination that a particular airframe-engine combination is a suitable type design for extended range operation, should apply to the cognizant type certificate holding aircraft certification office. An operator should apply similarly, except through their certificate holding office. The responsible aircraft certification office will then initiate an assessment of the airframe-engine combination in accordance with Paragraphs 8, 9, and Appendix 1 of this AC.

b. Criteria. The applicant should conduct an evaluation of failures and failure combinations based on engineering and operational consideration as well as acceptable fail-safe methodology. The analysis should consider effects of operations with a single engine, including allowance for additional stress that could result from failure of the first engine. Unless it can be shown that equivalent safety levels are provided or the effects of failure are minor, failure and reliability analysis should be used as guidance in verifying that the proper level of fail-safe design has been provided. The following criteria are applicable to the extended range operation of airplanes with two engines:

(1) Airframe systems should be shown to comply with Section 25.1309, of the Federal Aviation Regulations, Amendment 25-41.

(2) The propulsion systems should be shown to comply with Section 25.901, of the Federal Aviation Regulations, Amendment 25-40.

(i) Engineering and operational judgment applied in accordance with the guidance outlined in Appendix 1 should be used to show that the propulsion system can achieve the desired level of reliability. This determination of the propulsion system reliability is derived from a world-fleet data base containing all IFSD events, all significant engine reliability problems, and available data on cases of significant loss of thrust, including those where the engine failed or was throttled-back/shut down by the pilot. This determination should take due account of the approved maximum diversion time and rectification of identified engine design problems, as well as events where in-flight starting capability may be degraded.

(ii) Contained engine failure, cascading failures, consequential damage or failure of remaining systems or equipment should be assessed in accordance with Section 25.901 of the FARs.

(iii) In addition to the flightcrew fuel management discussed in Paragraph 10.e.(2)(vii), a means should be provided to alert the flightcrew of a low-fuel quantity condition. The alert should commence at a total fuel quantity available condition equivalent to no less than one-half hour operation at maximum continuous power.

(iv) It should be shown during type design evaluation that adequate engine limit margins exist (i.e., rotor speed, exhaust gas temperatures) for conducting extended duration single-engine operation during the diversion at all approved power levels and in all expected environmental conditions. This assessment should account for the effects of additional engine loading demands (e.g., anti-ice, electrical, etc.) which may be necessary during the single-engine flight phase associated with the diversion. (Reference Appendix 4, Paragraph 1a(5).)

(3) The safety impact of an uncontained engine failure should be assessed in accordance with Sections 25.903, 33.19, and 33.75 of the FAR.

(4) The APU installation, if required for extended range operations, should meet the applicable Part 25 provisions (Subpart E - Powerplant Provisions, through Amendment 25-46) and any additional requirements necessary to demonstrate its ability to perform the intended function as specified by the FAA following a review of the applicant's data. If a certain extended range operation may necessitate in-flight start and run of the APU, it must be substantiated that the APU has adequate reliability for that operation.

(5) Extended duration, single-engine operations should not require exceptional piloting skills and/or crew coordination. Considering the degradation of the performance of the airplane type with a single-engine inoperative, the increased flightcrew workload, and the malfunction of remaining systems and equipment,

the impact on flightcrew procedures should be minimized. Consideration should also be given to the effects of continued flight with an engine and/or airframe system inoperative on the flightcrew's and passengers' physiological needs (for example, temperature control).

(6) It should be demonstrated for extended duration single-engine operation, that the remaining power (electrical, hydraulic, pneumatic) will continue to be available at levels necessary to permit continued safe flight and landing, and to provide those services necessary for the overall safety of the passengers and crew. Unless it can be shown that cabin pressure can be maintained on single-engine operation at the altitude necessary for continued flight to a <u>suitable</u> airport, oxygen should be available to sustain the passengers and crew for the maximum diversion time.

(7) In the event of any single failure, or any combination of failures not shown to be extremely improbable, it should be shown that electrical power is provided for essential flight instruments, warning systems, avionics, communications, navigation, required route or destination guidance equipment, supportive systems and/or hardware and any other equipment deemed necessary for extended range operation to continue safe flight and landing at a <u>suitable</u> airport. Information provided to each pilot should be of sufficient accuracy for the intended operation.

(8) Three or more reliable, independent alternating current (AC) electrical power sources should be available. As a minimum, each electrical source should be capable of powering the items specified in Paragraphs 8.c.(4) and 8.c.(7). If one or more of the required electrical power sources are provided by an APU, hydraulic system, or ram air turbine, the following criteria apply as appropriate:

(i) The APU when installed, should meet the criteria in Paragraph 8.b.(4).

(ii) The hydraulic power source should be reliable. To achieve this reliability, it may be necessary to provide two or more independent energy sources (e.g., bleed air from two or more pneumatic sources).

(iii) Ram air turbine (RAT) deployment should be demonstrated to be sufficiently reliable in deployment and use. The RAT should not require engine dependent power for deployment.

(9) It should be shown that adequate status monitoring information and procedures on all critical systems are available for the flightcrew to make pre-flight, in-flight go/no-go and diversion decisions.

(10) Extended range operations are not permitted with time-related cargo fire limitations less than the approved maximum diversion time in still air conditions (including an allowance for 15 minutes holding and an approach and landing) determined by considering other relevant failures, such as an engine inoperative, and combinations of failures not shown to be extremely improbable.

(11) Airframe and propulsion ice protection should be shown to provide adequate capability (aircraft controllability, etc.) for the intended operation. This should account for prolonged exposure to lower altitudes associated with the engine-out diversion, cruise, holding, approach and landing.

(12) Although a hardware/design solution to a problem is preferred, if scheduled maintenance, replacement, and/or inspection are utilized to obtain type design approval for extended range operation, then the specific maintenance information should be easily retrievable and clearly referenced and identified in an appropriate maintenance document.

c. Analysis of Failure Effects and Reliability.

(1) General. The analysis and demonstration of airframe and propulsion system failure effects and reliability provided by the applicant should be based on inservice experience as required by Paragraph 9, and the expected longest diversion time for extended range routes likely to be flown with the airplane. If it is necessary in certain failure scenarios to consider less time due to time-limited systems, the next lower time of 75 or 120 minutes will be established as the approved diversion time.

(2) Propulsion Systems.

(i) An assessment of the propulsion systems reliability for particular airframe-engine combinations should be made in accordance with Appendix 1.

(ii) The analysis should consider:

(A) Effects of operation with a single-propulsion system (i.e. high-power demands, bleed requirements, etc.) and include probable damage that could result from failure of the first engine.

(B) Effects of the availability and management of fuel for propulsion system operation (i.e. crossfeed valve failures, fuel mismanagement, ability to distinguish and isolate leaks, etc.).

(C) Effects of other failures, external conditions, maintenance and crew errors that could jeopardize the operation of the remaining propulsion system should be examined.

(D) Effect of inadvertent thrust reverser deployment, if not shown to be extremely improbable (includes design and maintenance).

(3) Hydraulic Power and Flight Control. Consideration of these systems may be combined, since many commercial airplanes have full hydraulically-powered controls. For airplanes with all flight controls being hydraulically powered, evaluation of hydraulic system redundancy should show that single failures or failure combinations not shown to be extremely improbable do not preclude continued safe flight and landing at a suitable airport. As part of this evaluation, the loss of any two hydraulic systems and any engine should be assumed to occur unless it is established during failure evaluation that there are no sources of damage or the location of the damage sources are such that this failure condition will not occur.

(4) Electrical Power. Electric power is provided to a small group of instruments and devices required for continued safe flight and landing, and to a much larger group of instruments and devices needed to allow the flightcrew to cope effectively with adverse operating conditions. Multiple sources (engine driven generators, APU's, etc.) should be provided to meet both the "continued safe flight and landing requirements" and the "adverse conditions requirements" as amplified in AC 25.1309-1A. A review should be conducted of fail-safe and redundancy features supported by a statistical analysis considering exposure times established in Paragraph 8.c.(1).

(5) Equipment Cooling. The data should establish that the necessary electronic equipment for extended range operation has the ability to operate acceptably considering failure modes in the cooling system not shown to be extremely improbable. Adequate indication of the proper functioning of the cooling system should be demonstrated to ensure system operation prior to dispatch and during flight.

(6) Cargo Compartment. The cargo compartment design and fire protection system capability (if necessary) should be consistent with the following:

(i) Design. The cargo compartment fire protection system integrity and reliability should be suitable for the intended operation considering fire detection sensors, liner materials, etc.

(ii) Fire Protection. An analysis or tests should be conducted to show, considering approved maximum diversion in still air (including an allowance for 15-minute holding and/or approach and land), that the ability of the system to suppress or extinguish fires is adequate to ensure safe flight and landing at a suitable airport.

(7) Communication, Navigation, and Basic Flight Instruments (Altitude, Airspeed, Attitude and Heading). It should be shown that, under all combinations of propulsion and/or airframe system failures which are not extremely improbable, reliable communication, sufficiently accurate navigation, basic flight instruments, and any route and destination guidance needed to comply with contingency procedures for intended operation will be available to each pilot.

(8) Cabin Pressurization. A review of fail-safe and redundancy features should show that the loss of cabin pressure is improbable under single-engine operating conditions. FAA-approved airplane performance data should be available to verify the ability to continue safe flight and landing after loss of pressure and subsequent operation at a lower altitude.

(9) Cockpit and Cabin Environment. It should be shown that an adequate cockpit and cabin environment is preserved following all combinations of propulsion and electrical system failures which are not shown to be extremely improbable.

d. Assessment of Failure Conditions. In assessing the fail-safe features and effects of failure conditions, account should be taken of:

(1) The variations in the performance of the system, the probability of the failure(s), the complexity of the crew action, and the type and frequency of the relevant crew training.

(2) Factors alleviating or aggravating the direct effects of the initial failure condition, including consequential or related conditions existing within the airplane which may affect the ability of the crew to deal with direct effects, such as the presence of smoke, airplane accelerations, interruption of air-to-ground communication, cabin pressurization problems, etc.

(3) A flight test should be conducted by the manufacturer and witnessed by the FAA type certificate holding office to validate expected airplane flying qualities and performance considering engine failure, electrical power losses, etc. The adequacy of remaining airplane systems and performance and flightcrew ability to deal with the emergency considering remaining flight deck information will be assessed in all phases of flight and anticipated operating conditions. Depending on the scope, content, and review, by the responsible FAA Aircraft Certification Office, of the manufacturer's data base, this flight test could be used as a means for approving the basic aerodynamic and engine performance data used to establish the airplane performance identified in Paragraph 10.d.(6).

e. FAA Airplane Assessment Report. The assessment of the reliability of propulsion and airframe systems for a particular airframe-engine combination will be contained in an FAA Airplane Assessment Report. The report will be provided to the Transport Airplane Certification Directorate (FAA Northwest Mountain Region) for approval and to the directors of Flight Standards, and Aircraft Certification Service, for review and concurrence. Following approval of the report, the propulsion and airframe system recommendations will be included in an FAA-approved document that establishes the CMP standard requirements for the candidate airplane. This document will then be referenced in the Operations Specification and the Airplane Flight Manual.

f. <u>ETOPS Type Design Approval</u>. Upon satisfactory completion of the airplane evaluation through an engineering inspection and test program consistent with the type certification procedures of FAR Part 21 and sufficient inservice experience data:

(1) The type design approval will be reflected in the FAA-approved AFM or supplement, and Type Certification Data Sheet or Supplemental Type Certificate which contain directly or by reference the following pertinent information, as applicable:

(i) Special limitations (if necessary), including any limitations associated with a maximum diversion time established in accordance with Paragraph 8c(1).

(ii) Markings or placards (if required);

(iii) Revision to the performance section in accordance with paragraph 10d(6);

(iv) The airborne equipment, installation, and flightcrew procedures required for extended range operations;

(v) Description or reference to a document containing the approved airplane configuration CMP standard;

(vi) A statement to the effect that:

"The type design reliability and performance of this airframe-engine combination has been evaluated in accordance with AC 120-42A and found suitable for (state maximum diversion time) extended range operations with the incorporation of the approved airplane configuration CMP standard. This finding does not constitute approval to conduct extended range operations."

g. <u>Type Design Change Process</u>. The FAA directorate responsible for the certification of the type design will include the consideration of extended range operation in its normal monitoring and design change approval functions. Any significant problems which adversely effect extended range operation will be corrected. Modifications or maintenance actions to achieve or maintain the reliability objective of extended range operations will be incorporated into the type design CMP standard document. The FAA will normally coordinate this action with the affected industry. The Airworthiness Directive process will be utilized as necessary to effect a CMP standard change. The current CMP standard will be reflected in Part D of each ETOPS operator's operations specifications.

h. Continued Airworthiness. The type design CMP standard which establishes the suitability of an airplane for extended range operations defines the minimum standards for the operation. Incorporation of additional modifications or maintenance actions generated by an operator or manufacturer to enhance or maintain the continued airworthiness of the airplane may be made through the normal approval process. The operator or manufacturer (as appropriate) should thoroughly evaluate such changes to ensure that they do not adversely effect reliability or conflict with requirements for extended range approval.

9. INSERVICE EXPERIENCE. In establishing the suitability of a type design in accordance with Paragraph 8 of this AC and as a prerequisite to obtaining any operational approval, in accordance with the criteria of Paragraph 10 of this AC, it should be shown that an acceptable level of propulsion system reliability has been achieved in service by the world fleet for that particular airframe-engine combination. The candidate operator needs also to obtain sufficient maintenance and operation familiarity with the particular airframe-engine combination in question.

a. Prior to the type design approval, Paragraph 8, it should be shown that the world fleet of the particular airframe-engine combination for which approval is sought can or has achieved, as determined by the FAA (see Appendix 1), an acceptable and reasonably stable level of single propulsion system in-flight shutdown (IFSD) rate and airframe system reliability. Engineering and operational judgment applied in accordance with the guidance outlined in Appendix 1 will then be used to determine that the IFSD rate objective for all independent causes can be achieved. This assessment is an integral part of the determination in Paragraph 8.b.(2) for type design approval. This determination of propulsion system reliability is derived from a world fleet data base containing all in-flight shutdown events and significant engine reliability problems, in accordance with requirements of Appendix 1. This determination will take due account of the approved maximum diversion time, rectification of identified system problems, as well as events where in-flight starting capability may be degraded.

b. Each operator requesting approval to conduct extended range operations should have operational inservice experience appropriate to the operation proposed. Subparagraphs 9.b.(1)(2)(3) contain guidelines for requisite inservice experience. These guidelines may be reduced or increased following review and concurrence on a case-by-case basis by the Director, Flight

Standards Service. Any reduction or increase in inservice experience guidelines will be based on an evaluation of the operator's ability and competence to achieve the necessary reliability for the particular airframe-engine combination in extended range operations. For example, a reduction in inservice experience may be considered for an operator who can show extensive inservice experience with a related engine on another airplane which has achieved acceptable reliability. In contrast, an increase in inservice experience may be considered for those cases where heavy maintenance has yet to occur and/or abnormally low number of takeoffs have occurred.

(1) 75-Minute Operation. Consideration may be given to the approval of 75-minute extended range operations for operators with minimal or no inservice experience with the airframe-engine combination. This determination considers such factors as the proposed area of operations, the operator's demonstrated ability to successfully introduce airplanes into operations, and the quality of the proposed maintenance and operations programs.

(2) 120-Minute Operation. Each operator requesting approval to conduct extended range operations with a maximum diversion time of 120 minutes (in still air) should have 12 consecutive months of operational inservice experience with the specified airframe-engine combination. Inservice experience guidelines may be increased or decreased by the Director, Flight Standards Service, as noted in Paragraph 9b.

(3) 180-Minute Operation. Each operator requesting approval to conduct extended range operations with a maximum diversion time of 180 minutes (in still air) should have previously gained 12 consecutive months of operational inservice experience with the specified airframe-engine combination in conducting 120-minute extended range operations. Inservice experience guidelines may be reduced or increased by the Director, Flight Standards Service, as noted in Paragraph 9b. Likewise, the substitution of inservice experience which is equivalent to the actual conduct of 120-minute ETOPS operations will also be established by the Director, Flight Standards Service, on a case-by-case basis.

10. OPERATIONAL APPROVAL CONSIDERATIONS. Paragraphs 10.a. through 10.h. detail the criteria for operational approval of extended range operations with a maximum diversion time of 120 minutes to an en route alternate (at single-engine inoperative cruise speed in still air). Appendices 4 and 5 serve two functions; first, they provide expanded explanation of the elements contained in this advisory circular and second, they serve to differentiate the criteria for approval of operations less than 120 minutes (75 minutes) and beyond 120 minutes (180 minutes). For approval of 75-minute operations, only certain requirements of this AC apply. (See Appendix 5.)

a. Requesting Approval. Any operator requesting approval under FAR Section 121.161 for extended range operations with two-engine airplanes (after providing an acceptable evaluation of the considerations in Paragraphs 8 and 9) should submit the requests, with the required supporting data, to the certificate-holding district office at least 60 days prior to the proposed start of extended range operation with the specific airframe-engine combination. In considering an application from an operator to conduct extended range operations, an assessment should be made of the operator's overall safety record, past performance, flightcrew training, and maintenance programs. The data provided with the request should substantiate the operator's ability and competence to safely conduct and support these operations and should include the means used to satisfy the considerations outlined in this paragraph. (Any reliability assessment obtained, either through analysis or service experience, should be used as guidance in support of operational judgments regarding the suitability of the intended operation.)

b. Assessment of the Operator's Propulsion System Reliability. Following the accumulation of adequate operating experience by the world fleet of the specified airframe-engine combination and the establishment of an IFSD rate objective in accordance with Appendix 1 for use in ensuring the propulsion system reliability necessary for extended range operations, an assessment should be made of the applicant's ability to achieve and maintain this level of propulsion system reliability. This assessment should include trend comparisons of the operator's data with other operators as well as the world fleet average values, and the application of a qualitative judgment that considers all of the relevant factors. The operator's past record of propulsion system reliability with related types of power units should also be reviewed, as well as its record of achieved systems reliability with the airframe-engine combination for which authorization is sought to conduct extended range operations.

c. Engineering Modifications and Maintenance Program Considerations. Although these considerations are normally part of the operator's continuing airworthiness program, the maintenance and reliability program may need to be supplemented in consideration of the special requirements of extended range operation (Appendix 4). The following items, as part of the operator's program, will be reviewed to ensure that they are adequate for extended range operations:

(1) Engineering Modifications. The operator should provide to the certificate-holding district office all titles and numbers of all modifications, additions, and changes which were made in order to substantiate the incorporation of the CMP standard in the airplanes used in extended range operation.

(2) Maintenance Procedures. Following approval of the changes in the maintenance and training procedures, substantial

changes to maintenance and training procedures, practices, or limitations established to qualify for extended range operations should be submitted to the certificate-holding district office 60 days before such changes may be adopted.

(3) Reliability Reporting. The reliability reporting program as supplemented and approved, should be implemented prior to and continued after approval of extended range operation. Data from this process should result in a suitable summary of problem events, reliability trends and corrective actions and be provided regularly to the certificate-holding district office. Appendix 4 contains additional information concerning propulsion and airframe system reliability monitoring and reporting.

(4) Approved modifications and inspections which would maintain the reliability objective for the propulsion and airframe systems as a consequence of Airworthiness Directive (AD) actions and revised CMP standards should be promptly implemented. Other recommendations made by the engine and airframe manufacturers should also be considered for prompt implementation. This would apply to both installed and spare parts.

(5) Procedures and centralized control process should be established which would preclude an airplane being dispatched for extended range operation after propulsion system shutdown or primary airframe system failure on a previous flight, or significant adverse trends in system performance, without appropriate corrective action having been taken. Confirmation of such action as being appropriate, in some cases, may require the successful completion of one or more nonrevenue or non-ETOP revenue flights (as appropriate) prior to dispatch on an extended range operation.

(6) The program used to ensure that the airborne equipment will continue to be maintained at the level of performance and reliability necessary for extended range operations.

(7) Engine condition monitoring program.

(8) Engine oil consumption monitoring program.

d. Flight Dispatch Considerations.

(1) General. The flight dispatch considerations specified in this section are in addition to, or amplify, the requirements contained in FAR Part 121 and specifically apply to extended range operations. Although many of the considerations in this AC are currently incorporated into approved programs for other airplanes or route structures, the unique nature of extended range operations with two-engine airplanes necessitates a reexamination of these operations to ensure that the approved programs are adequate for this purpose.

(2) Master Minimum Equipment List (MMEL). System redundancy levels appropriate to extended range operations should be reflected in the MMEL. An operator's MEL may be more restrictive than the MMEL considering the kind of ER operation proposed and equipment and service problems unique to the operator. Systems considered to have a fundamental influence on flight safety may include, but are not limited to the following:

(i) Electrical, including battery;

(ii) Hydraulic;

(iii) Pneumatic;

(iv) Flight instrumentation;

(v) Fuel;

(vi) Flight control;

(vii) Ice protection;

(viii) Engine start and ignition;

(ix) Propulsion system instruments;

(x) Navigation and communications;

(xi) Auxiliary power-units;

(xii) Air conditioning and pressurization;

(xiii) Cargo fire suppression;

(xiv) Emergency equipment; and

(xv) Any other equipment necessary for extended range operations.

(3) Communication and Navigation Facilities. An airplane should not be dispatched on an extended range operation unless:

(i) Communications facilities are available to provide under normal conditions of propagation at the normal one-engine inoperative cruise altitudes, reliable two-way voice communications between the airplane and the appropriate air traffic control unit over the planned route of flight and the routes to any suitable alternate to be used in the event of diversion;

(ii) Nonvisual ground navigation aids are available and located so as to provide, taking account of the navigation equipment installed in the airplane, the navigation accuracy necessary for the planned route and altitude of flight, and the routes to any alternate and altitudes to be used in the event of an engine shutdown; and

(iii) Visual and nonvisual aids are available at the specified alternates for the authorized types of approaches and operation minima.

(4) Fuel and Oil Supply.

(i) General. An airplane should not be dispatched on an extended range operation unless it carries sufficient fuel and oil to meet the requirements of FAR Part 121, and any additional fuel that may be determined in accordance with subparagraph 10.d.(4)(ii). In computing fuel requirements, advantage may be taken of driftdown and at least the following should be considered as applicable:

(A) Current forecast winds and meteorological conditions along the expected flightpath at one-engine inoperative cruising altitude and throughout the approach and landing;

(B) Any necessary operation of ice protection systems and performance loss due to ice accretion on the unprotected surfaces of the airplane;

(C) Any necessary operation of auxiliary power units;

(D) Loss of airplane pressurization and air conditioning; consideration should be given to flying at an altitude meeting oxygen requirements in the event of loss of pressurization;

(E) An approach followed by a missed approach and a subsequent approach and landing;

(F) Navigational accuracy necessary; and

(G) Any known Air Traffic Control (ATC) constraints.

(ii) Critical Fuel Reserves. In establishing the critical fuel reserves, the applicant is to determine the fuel necessary to fly to the most critical point and execute a diversion to a suitable alternate under the conditions outlined in subparagraph 10.d.(4)(iii)--the Critical Fuel Scenario. These critical fuel reserves should be compared to the normal FAR Part 121 requirements for the flight. If it is determined by this comparison that the fuel to complete the critical fuel scenario exceeds the fuel that would be on board at the most critical point, as determined by Part 121 requirements of the FAR, additional fuel should be included to the extent necessary to safely complete the critical fuel scenario. In consideration of the items listed in subparagraph 10.d.(4)(i), the critical fuel scenario should allow for: a contingency figure of 5 percent added to the calculated fuel burn from the critical point to allow for errors in wind forecasts, a 5 percent penalty in fuel mileage**, any Configuration Deviation List items, both airframe and engine anti-icing; and account for ice accumulation on unprotected surfaces if icing conditions are likely to be encountered during the diversion. If the APU is a required power source, then its fuel consumption should be accounted for during the appropriate phase(s) of flight. (**In lieu of an applicant's established value for inservice deterioration in cruise fuel mileage.)

(iii) Critical Fuel Scenario. The following describes a scenario for a diversion at the most critical point. The applicant should confirm the scenario to be used in determining the critical fuel reserve necessary is operationally the most critical considering both time and airplane configuration (e.g., 2 engine versus 1 engine at 10,000 feet, nonstandard airplane configuration not shown to be extremely improbable, paragraph 8.c.(2)(ii)(D)).

(A) At the critical point, consider simultaneous failure of an engine and the pressurization system (critical point based on time to a suitable alternate at the approved one-engine inoperative cruise speed).

(B) Immediate descent to and continued cruise at 10,000 feet at the approved one-engine inoperative cruise speed or continued cruise above 10,000 feet if the airplane is equipped with sufficient supplemental oxygen in accordance with FAR Section 121.329.

(C) Upon approaching destination, descent to 1,500 feet above destination, hold for 15 minutes, initiation of an approach followed by a missed approach and then execution of a normal approach and landing.

(5) Alternate Airports. An airplane should not be dispatched on an extended range operation unless the required takeoff, destination and alternate airports, including suitable en route alternate airports to be used in the event of engine shutdown or airplane system failure(s) which require a diversion, are listed in the cockpit documentation (e.g., computerized flight plan). Suitable en route alternates should also be identified and listed in the dispatch release for all cases where the planned route of flight contains a point more than one hour flying time at the one-engine inoperative speed from an adequate airport. Since these suitable en route alternates serve a different purpose than the destination alternate airport and would normally be used only in the event of an engine failure or the loss of primary airplane systems, an airport should not be listed as a suitable en route alternate unless:

(i) The landing distances required as specified in the AFM for the altitude of the airport, for the runway expected to be used, taking into account wind conditions, runway surface conditions, and airplane handling characteristics, permit the airplane to be stopped within the landing distance available as declared by the airport authorities and computed in accordance with FAR Part 121.197.

(ii) The airport services and facilities are adequate for the applicant operator's approved approach procedure(s) and operating minima for the runway expected to be used; and

(iii) The latest available forecast weather conditions for a period commencing one hour before the established earliest time of landing and ending one hour after the established latest time of landing at that airport, equals or exceeds the authorized weather minima for en route alternate airports in Appendix 3. In addition, for the period commencing one hour before the established earliest time of landing, and ending one hour after the established latest time of landing at that airport, the forecast crosswind component, including gusts, for the landing runway expected to be used should be less than the maximum permitted crosswind for landing.

(iv) During the course of the flight, the flightcrew should be informed of any significant changes in conditions at designated en route alternates. Prior to a 120-minute extended range flight proceeding beyond the extended range entry point, the forecast weather for the time periods established in subparagraph 10d(5)(iii), landing distances, and airport services and facilities at designated en route alternates should be evaluated. If any conditions are identified (such as weather forecast below landing minima) which would preclude safe approach and landing, then the pilot should be notified and an acceptable alternate(s) selected where safe approach and landing can be made.

(6) Airplane Performance Data. No airplane should be dispatched on an extended range flight unless the operator's Operations Manual contains sufficient data to support the critical fuel reserve and area of operations calculation. The following data should be based on FAA-approved (see Paragraph 8.d.(3)) information provided or referenced in the Airplane Flight Manual.

(i) Detailed one-engine inoperative performance data including fuel flow for standard and nonstandard atmospheric conditions and as a function of airspeed and power setting, where appropriate, covering

(A) Driftdown (includes net performance);

(B) Cruise altitude coverage including 10,000 feet;

(C) Holding;

(D) Altitude capability (includes net performance); and

(E) Missed approach.

(ii) Detailed all-engine-operating performance data, including nominal fuel flow data, for standard and nonstandard atmospheric conditions and as a function of airspeed and power setting, where appropriate, covering:

(A) Cruise (altitude coverage including 10,000 feet); and

(B) Holding.

(iii) Details of any other conditions relevant to extended range operations which can cause significant deterioration of performance, such as ice accumulation on the unprotected surfaces of the airplane, RAM Air Turbine (RAT) deployment, thrust reverser deployment, etc.

(iv) The altitudes, airspeeds, thrust settings, and fuel flow used in establishing the ETOPS area of operations for each airframe-engine combination must be used in showing the corresponding terrain and obstruction clearances in accordance with FAR Section 121.191.

e. Flightcrew Training, Evaluation, and Operating Manuals.

(1) Adequacy of Flightcrew Training and Operating Manuals. The FAA will review inservice experience of critical and essential airplane systems. The review will include system reliability levels and individual event circumstances, including crew actions taken in response to equipment failures or unavailabilities. The purpose of the review will be to verify the adequacy of information provided in training programs and operating manuals. The aviation industry should provide information for and participate in these reviews. The FAA will use the information resulting from these reviews to modify or update flightcrew training programs, operating manuals, and checklists, as necessary.

(2) Flightcrew Training and Evaluation Program. The operator's training program in respect to extended range operations should provide training for flight crewmembers followed by subsequent evaluations and proficiency checks in the following areas:

(i) Performance.

(A) Flight planning, including all contingencies.

(B) Flight performance progress monitoring.

(ii) Procedures.

(A) Diversion procedures.

(B) Use of appropriate navigation and communication systems.

(C) Abnormal and emergency procedures to be followed in the event of foreseeable failures, including:

(1) Procedures for single and multiple failures in flight that would precipitate go/no-go and diversion decisions.

(2) Operational restrictions associated with these failures including any applicable MEL considerations.

(3) Procedures for air start of the propulsion systems, including the APU, if required.

(4) Crew incapacitation.

(D) Use of emergency equipment including protective breathing and ditching equipment.

(E) Procedures to be followed in the event that there is a change in conditions at designated en route alternates which would preclude safe approach and landing.

(F) Understanding and effective use of approved additional or modified equipment required for extended range operations.

(G) Fuel Management. Flightcrew should be trained on the fuel management procedures to be followed during the en route portion of the flight. These procedures should provide for an independent cross-check of fuel quantity indicators. For example, fuel flows could be used to calculate fuel burned and compared to indicated fuel remaining.

(3) ETOPS Check Airman. The operator should designate specific ETOPS check airman. The objective of the ETOPS check airman program should be to ensure standardized flightcrew practices and procedures and also to emphasize the special nature of ETOPS operations. Only airmen with a demonstrated

understanding of the unique requirements of ETOPS should be designated as a check airman.

f. Operational Limitations.

(1) Area of Operation.

(i) An operator may be authorized to conduct extended range operations within an area where the diversion time at any point along the proposed route of flight to an adequate airport is 75, 120 or 180 minutes at the approved one-engine cruise speed (under standard conditions in still air). Appendices 1, 4, and 5 provide criteria for operation at the different diversion times.

(ii) The area which meets the considerations in Paragraph 9.f.(1)(i) may be approved for extended range operations with two-engine airplanes and should be specified in the operations specifications as the authorized area of operations.

(2) Flight Dispatch Limitation. The flight dispatch limitation should specify the maximum diversion time from a suitable airport an operator can conduct a particular extended range operation. The maximum diversion time at the approved one-engine inoperative cruise speed (under standard conditions in still air) should not be any greater than the value established by subparagraph 10.f.(1)(i).

(i) Use of Maximum Diversion Time. The flight dispatch considerations should ensure that extended range operation is limited to flight plan routes where the approved maximum diversion time to suitable airports can be met. Operators should provide for:

(A) Compliance with FAR Section 121.565 where, upon occurrence of an in-flight shutdown of an engine, the pilot should promptly initiate diversion to fly to and land at the nearest airport, in point of time, determined to be suitable by the flightcrew.

(B) A practice to be established such that in the event of a single or multiple primary system failure, the pilot will initiate the diversion procedure to fly and land at the nearest suitable airport, unless it has been demonstrated that no substantial degradation of safety results from continuation of the planned flight.

(ii) Criteria for Maximum Diversion Times. The criteria for different maximum diversion times are detailed in Appendices 1, 4, and 5.

(3) Contingency procedures should not be interpreted in

anyway which prejudices the final authority and responsibility of the pilot in command for the safe operation of the airplane.

g. Operations Specifications.

(1) An operator's two-engine airplane should not be operated on an extended range flight unless authorized by operations specifications approval (both maintenance and operations).

(2) Operations specifications for extended range operations should specifically include provisions covering at least the following:

(i) Part D should define the particular airframe-engine combinations, including the current approved CMP standard required for extended range operation as normally identified in the AFM (paragraph 8.f.).

(ii) Authorized area of operation.

(iii) Minimum altitudes to be flown along planned and diversionary routes.

(iv) The maximum diversion time, at the approved one-engine inoperative cruise speed (under standard conditions in still air), that any point on the route the airplane may be from a suitable airport for landing.

(v) Airports authorized for use, including alternates, and associated instrument approaches and operating minima.

(vi) The approved maintenance and reliability program (ref. Appendix 4) for extended range operations including those items specified in the type design approved CMP standard.

(vii) Identification of those airplanes designated for extended range operation by make and model as well as serial and registration numbers.

(viii) Airplane Performance Reference.

h. Operational Validation Flight. The operator should demonstrate, by means of an FAA-witnessed validation flight using the specified airframe-engine combination, that it has the competence and capability to safely conduct and adequately support the intended operation. (This is in addition to the flight test required for type design approval in Paragraph 8.d.(3)). The Director, Flight Standards Service, will determine the conditions for each operator's validation flight following a review on a case-by-case basis of the operator's experience and the proposed operation. The following emergency conditions should be demonstrated during the validation flight unless successful demonstration of these conditions has been witnessed by the FAA in an acceptable simulation prior to the validation flight:

(1) Total loss of thrust of one-engine; and total loss of engine-generated electrical power;

OR,

(2) Any other condition considered to be more critical in terms of airworthiness, crew workload, or performance risk.

i. Extended Range Operations Approval. Following a type design approval for extended range operations in accordance with paragraph 8 and satisfactory application of the criteria in paragraphs 9 and 10 and prior to the issuance of operations specifications, the operator's application, as well as, the certificate-holding district office's principal inspectors' (Principal Maintenance Inspector, Principal Avionics Inspector, Principal Operations Inspector) recommendations and supporting data should be forwarded to the Director, Flight Standards Service, for review and concurrence. Following the review and concurrence by the Director, the operational validation flight should be conducted in accordance with any additional guidance specified in the review and concurrence. When the operational validation flight has been evaluated and found acceptable, an applicant may be authorized to conduct extended range operations with the specified airframe-engine combination. Approval to conduct ETOP is made by the issuance of operations specifications containing appropriate limitations.

11. CONTINUING SURVEILLANCE. The fleet average IFSD rate for the specified airframe-engine combination will continue to be monitored in accordance with Appendices 1 and 4. As with all other operations, the certificate-holding district office should also monitor all aspects of the extended range operations it has authorized to ensure that the levels of reliability achieved in extended range operations remain at the necessary levels as provided in Appendix 1, and that the operation continues to be conducted safely. In the event that an acceptable level of reliability is not maintained, significant adverse trends exist, or if significant deficiencies are detected in the type design or the conduct of the ETOPS operation, the certificate-holding district office should initiate a special evaluation, impose operational restriction, if necessary, and stipulate corrective action for the

operator to adopt to resolve the problems in a timely manner. The certificate-holding district office should alert the Type Certification Office when a special evaluation is initiated and provide for their participation.

Anthony J. Broderick
Associate Administrator for
Regulation and Certification

APPENDIX 1. PROPULSION SYSTEM RELIABILITY ASSESSMENT

1. ASSESSMENT PROCESS. In order to establish if a particular airframe-engine combination has satisfied the current propulsion system reliability requirements for extended range operations, thorough assessment will be conducted by a group of FAA specialists, the Propulsion System Reliability Assessment Board (PSRAB) utilizing all the pertinent propulsion system data and information available (includes the APU, if required). Engineering and operational judgment supported by the relevant statistics will be used to determine current propulsion system reliability. The findings of the specialist group will be included in the FAA Airplane Assessment Report.

a. Service Experience. To provide a reasonable indication of airplne propulsion system reliability trends and to reveal problem areas, a certain amount of service experience will be required. In general, extended range airframe-engine combination reliability assessments concern two major categories; those supporting up to 120 minutes maximum diversion time operations and those support operations beyond 120 minutes maximum diversion times. A special case-by-case operational approval may be granted for 75-minute diversion routes and require limited evaluation of service experience at the time of the application.

(1) Operations up to 120 Minutes. Normally, accumulation of at least 250,000 engine hours in the world fleet will be necessary before the assessment process can produce meaningful results. This number of hours may be reduced if adequate compensating factors are identified which give a reasonable equivalent data base as established by the PSRAB. Where experience on another airplane is applicable to a candidate airplane, a significant portion of the 250,000 hours experience should normally be obtained by the candidate airplane. In the event that a particular engine is derived from an existing engine, the required operational experience is subject to establishing the degree of hardware commonality and operating similarities.

(2) Operations beyond 120 Minutes (180 minutes). Suitability to operate the airplane beyond 120 minutes will not be considered until operational experience in 120 minute extended range service clearly indicates further credit is appropriate. This would generally include at least one year of service experience with an ETOP configured fleet at 120-minute operation with a corresponding high level of demonstrated propulsion system reliability.

(3) 75-Minute Operation Authorization. In this category, service experience of the airframe-engine combination may be less than the 250,000 hours as provided in subparagraph a(1). It must be shown that sufficient favorable experience has been accumulated, demonstrating a level of reliability appropriate for

75-minute extended range operation. As detailed earlier in the Advisory Circular, a particular operator may receive a special 75-minute authorization following review on a case-by-case basis by the Director, Flight Standards Service.

b. Reliability Data Base. To adequately assess propulsion system reliability, consideration of the proposed maximum diversion time, for extended range type design approval, certain world-fleet data and information are required. The PSRAB intends to maximize the use of existing sources and kinds of data generally available; however, additional data may be required in certain cases. In support of applications for extended range type design approval, data should be provided from various sources to ensure completeness; i.e., engine manufacturer, operator, and airplane manufacturer. Data so provided should include all event descriptions, qualifications, and any pertinent details necessary to help determine the impact on propulsion system reliability. These data should include:

(1) A list of all engine shutdown events both ground and in flight for all causes (excluding normal training events) including flameout. The list should provide identification (engine and airplane model and serial number), engine configuration and modification history, engine position, circumstances leading up to the event, phase of flight or ground operation, weather/environmental conditions, and reason for shutdown. In addition, similar information should be provided for all occurrences where control or desired thrust level was not attained.

(2) Unscheduled engine removal rate (accumulated 6 and 12 months), removal summary, time history of removal rate and primary causes for unscheduled engine removal.

(3) Dispatch delays, cancellations, aborted takeoffs (includes those induced by maintenance or crew error) and en route diversions chargeable to the propulsion system.

(4) Total engine hours and cycles and engine hour population (age distribution).

(5) Mean time between failure of propulsion system components that affect reliability.

(6) IFSD rate based on a 6- and 12-month rolling average.

(7) Additional data as specified by the PSRAB.

c. Risk Management and the Risk Model. In order to assure that the risks of increased diversion times are acceptable, a risk model has been constructed. The risk model is based upon the known service records of an established large fleet of twin-engine civil transport-turbo fan powered airplane. The service experience of this "<u>base fleet</u>" has been very satisfactory and reflective of a high level of safety in its propulsion systems. It has achieved an average in-flight shutdown rate of approximately .02/1000 hours for a 10-year period while flying predominately on routes conforming to the requirements of FAR Section 121.161 (i.e., flight paths within 60 minutes flying time from a adequate airport).

(1) The risk of engine failure during a single-engine diversion event is directly related to the diversion flight time and the propulsion system reliability or IFSD rate. This assumes the failure of the first engine, which causes the diversion, is unrelated to the probability of failure of the second engine during the diversion. Common cause or related failure modes will be discussed in Paragraph 1(d). The product of IFSD rate and diversion time can be designated as a risk factor for the diversion and identified as (λT). For the base fleet of .02/1000 IFSD rate and 60 minutes maximum diversion, (λT) would be (.02/1000)(60). Identifying this base fleet risk factor as (λT)*, other combinations of IFSD rates and diversion times can be ratioed to this base risk factor to determine ETOP relative risk, (λT)/(λT)*. For ETOP diversion times of 60 minutes and IFSD rates of .02/1000, the relative risk factor equals 1.0. This relationship is shown in Figure 1.

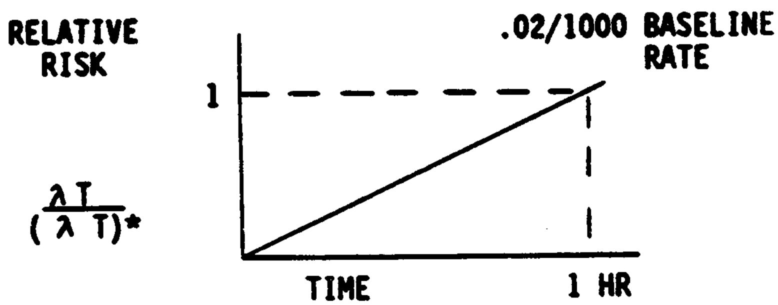

FIGURE 1

(2) Extending this model to a family of IFSD rates and diversion times, Figure 2 depicts the relationship between diversion time, IFSD rate, and risk relative to the base fleet during the diversion:

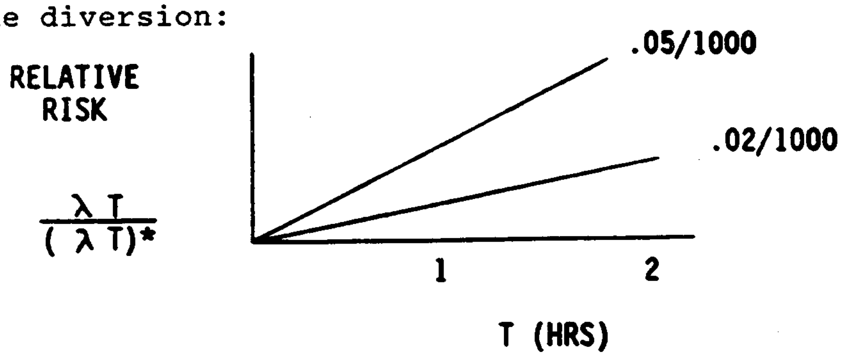

FIGURE 2

2. RELIABILITY LEVELS. As discussed in Paragraph 1, in order to ensure that risks associated with increased diversion times are acceptable, reliabilities of ETOP propulsion systems must be shown to approach or equal those of the highly reliable base fleet of .02/1000 and the appropriate operational and maintenance requirements implemented (see Figure 3).

a. Operations up to 120 Minutes. The overall fleet reliability should approach or achieve that of the highly reliable base fleet following incorporation of the appropriate configuration maintenance and operational requirements. Propulsion system maturity rates have suggested that incorporation of propulsion system improvements following review of 250,000 hours service experience have yielded an approximate .03/1000 improvement in IFSD reliability. Given the IFSD objective of approximately .02/1000 hours and the potential improvement rate of .03/1000 hours, the extended range operation start threshold can be established at approximately .05/1000 hours (see Figure 3). It should be noted that this is threshold and specific circumstances in fleet reliability data such as confidence in problem resolution, types of failures, etc., could be relevant in establishing a start threshold other than .05/1000.

b. Operations Beyond 120 Minutes. The overall fleet reliability should achieve that of the highly reliable base fleet prior to approval. Only those airframe-engine combinations exhibiting the highest levels of overall reliability will be found satisfactory for this type of operation (see Figure 3). In addition, it will normally be a necessary prerequisite for these airplanes to have at least one year of satisfactory ETOP service involving 120 minutes or less operation under conditions of this AC.

c. Reliability Targets-Summary. Utilizing the risk model, it can be shown that when progressing from the entry level required reliability to the target level reliability (achieved for 180 minutes), the overall risk is not adversely impacted considering respective increases in diversion time. (See Figure 3.)

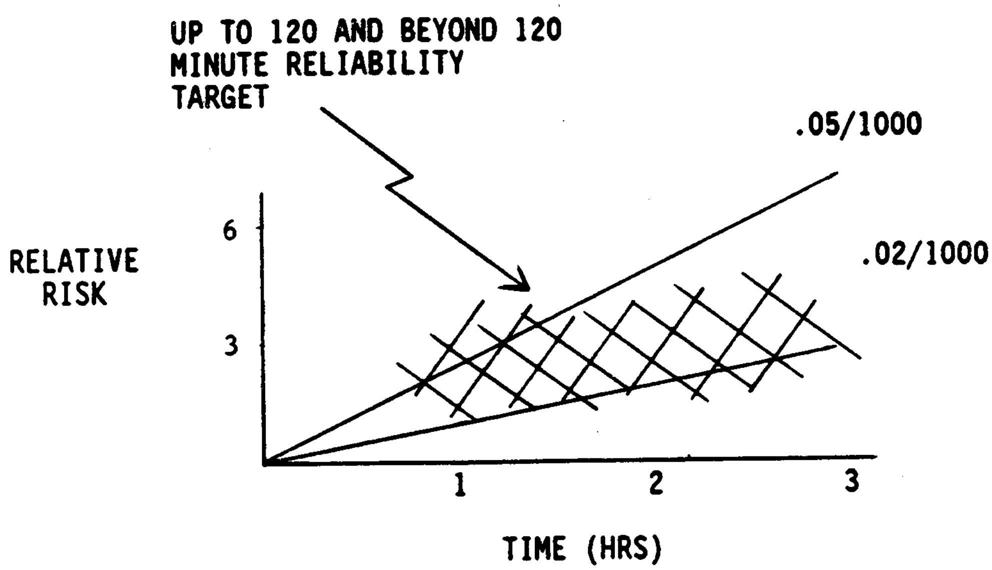

FIGURE 3

d. Risk Model Corroboration with Analysis. As a check of the conservatism for reliability levels identified by the risk model, an analysis can be performed which, given certain assumptions, can corroborate the model targets and identify areas of importance where on-going design, operation, and maintenance vigilance must be continued. In the construction of such an analysis, it is assumed that the probability of total thrust loss on any given twin engine airplane flight is made up of those engine failure mechanisms which are independent events (e.g., left engine failure independent from right engine failure) and these engine failure events which are related to a common source (e.g., left and right engines fail as a result of a common or related event).
This may be shown as:

$$P_{TT} = P_{TI} + P_{TC} \quad (1)$$

P_{TT} = Total probability of complete thrust loss on any given flight.

P_{TI} = Probability of complete thrust loss on flight due to independent causes.

P_{TC} = Probability of complete thrust loss on flight due to common causes.

In determination of the probability of total thrust loss due to independent causes (P_{TI}), International Civil Aviation Organization Report No. AN-WP/5593 titled "Extended Range Operation of Twin-Engine Commercial Air Transport Aeroplanes," dated February 15, 1984, contains an analytical assessment of in-flight shutdown rate, flight time, and diversion time as equated to an observed assessment of commercial transport aircraft accidents worldwide for a recent several year period. This relationship, as derived in this study, is shown as:

IFSD Rate $$\sqrt{\frac{10^{-8}\ (.6 + .4T)}{TY}} \qquad (2)$$

Where: T = intended duration of flight
Y = diversion time

As an example, for a flight of seven hours and a diversion time of two hours, equation (2) identifies an IFSD of .05/1000 as necessary, while for a diversion time of three hours, .04/1000 is necessary to provide a level of probability supporting the reference world accident rate. As can be seen, the risk model identified in paragraph 1.c. of this Appendix requires an achieved IFSD rate of one half that calculated using the ICAO assessment. It is believed essential that the ETOPS IFSD rate provided by paragraph 1.c. of this Appendix be required considering the influence of common cause failure mechanisms (P_{TC}) as well as the uncertainties associated with assumption identified in the ICAO study.

Although there has been no suitable analytical models developed for assessment of the probability of complete thrust loss in flight due to common cause events (P_{TC}), it is considered that by establishment of highly reliable propulsion systems through achievement of low in-flight shutdown rates, continual engine and airplane design monitoring for those potential common mode service difficulties, and vigilant maintenance and operational practices as identified in Appendices 4 and 5, risks associated with total thrust loss can be maintained at acceptable low levels (Figure 4).

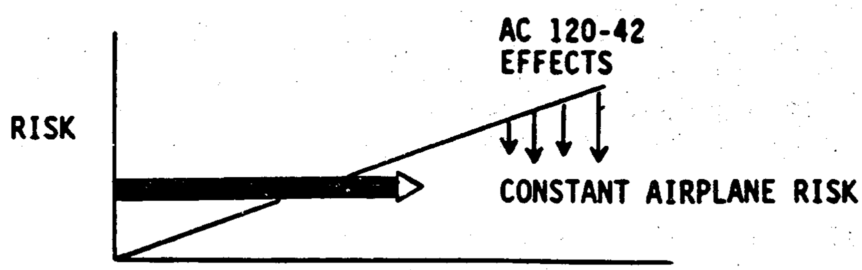

FIGURE 4

e. Propulsion System Approval Considerations. The determination that a propulsion system is suitable per the assessment considerations of either of the two major categories is provided by the PSRAB. Table 1 identifies the constituent elements of the two major categories of approval considerations.

Table 1.

Propulsion System Approval Considerations

Up to 120 Minute Operation	Greater Than 120 Minute Operation
o 250,000 engine hours (significant portion with experience candidate airplane).	o same plus at least additional one year with the approved extended range configured fleet.
o achieve an IFSD of approximately .05/1000 (the objective is continuing improvement towards a rate of .02/1000 hours).	o achieve and maintain an IFSD of approximately .02/1000 hours.
o Periodic review of propulsion system data and service experience, and revise the CMP standard as appropriate.	o same - schedule for incorporation of CMP standards requirements, may be shorter.

3. ENGINEERING ASSESSMENT. The methodology to be used by the FAA in determining adequate propulsion system reliability will be a problem-oriented approach using fail-safe concepts, an assessment of the maturation of the propulsion system, the achieved level of IFSD rate, engineering and operational judgment and reliability analysis, and will consist of:

a. An analysis, on a case-by-case basis, of all significant failures, defects and malfunctions experienced in service (or during testing) for the airframe-engine combination being addressed. Significant failures are principally those causing or resulting in in-flight shutdown or flameout of the engine(s), but may also include unusual ground failures, uncommanded thrust reduction, and/or unscheduled removal of engines from the airplane. In making the assessment, consideration will be given to the following:

(1) The type of engine, previous experience, similarity in hardware and operating characteristics with other engines, and the engine operating rating limit to be used with one-engine shutdown.

(2) The trends in cumulative and 6- and 12-month rolling average, updated quarterly, of in-flight shutdown rates versus propulsion system flight hours and cycles.

(3) The effect of corrective modifications, maintenance, etc., on the possible future reliability of the propulsion system.

(4) Maintenance actions recommended and performed and their effect on engine and APU failure rates.

(5) The accumulation of operational experience which covers the range of environmental limitations likely to be encountered.

(6) Intended maximum flight duration and approved maximum diversion time.

b. An assessment of the corrective actions taken for each problem identified with the objective of verifying that the action is sufficient to correct the deficiency.

c. When each identified significant deficiency has a corresponding FAA-approved corrective action and when all corrective actions are satisfactorily incorporated and verified, the PSRAB determines that an acceptable level of reliability can be achieved. Statistical corroboration will also be utilized. When foreign manufacturer's and/or operator's data are being evaluated, the respective civil airworthiness authorities will be offered the opportunity to participate. They will be briefed by the PSRAB during the proceedings and provided a copy of the final report for their review.

4. PSRAB FINDINGS. Once an assessment has been completed and the PSRAB has documented its findings, the FAA will declare whether or not the particular airframe-engine combination satisfies the relevant considerations of this AC. Items recommended to qualify the propulsion system, maintenance requirements, and limitations will be included in the Airplane Assessment Report (Paragraph 8.e.).

5. ON-GOING FLEET MONITORING. In order to ensure that the desired level of reliability is maintained, the PSRAB will continuously monitor reliability data and periodically review its original findings. In addition the FAA document containing the CMP standard will be revised as necessary.

APPENDIX 2. THE FAA FAIL-SAFE DESIGN CONCEPT

1. FAA FAIL-SAFE DESIGN CONCEPT. The FAR Part 25 airworthiness standards are based on, and incorporate, the objectives, and principles or techniques, of the fail-safe design concept, which considers the effects of failures and combinations of failures in defining a safe design. The following basic objectives pertaining to failures apply:

a. In any system or subsystem, the failure of any single element, component, or connection during any one flight (brake release through ground deceleration to stop) should be assumed, regardless of its probability. Such single failures should not prevent continued safe flight and landing, or significantly reduce the capability of the airplane or the ability of the crew to cope with the resulting failure conditions.

b. Subsequent failures during the same flight, whether detected or latent, and combinations thereof, should also be assumed, unless their joint probability with the first failure is shown to be extremely improbable.

2. FAIL-SAFE PRINCIPLES AND/OR TECHNIQUES. The fail-safe design concept uses the following design principles or techniques in order to ensure a safe design. The use of only one of these principles or techniques is seldom adequate. A combination of two or more is usually needed to provide a fail-safe design; i.e., to ensure that major failure conditions are improbable and that catastrophic failure conditions are extremely improbable.

a. Designed Integrity and Quality. Including Life Limits, to ensure intended function and prevent failures.

b. Redundancy or Backup Systems to enable continued function after any single (or other number of) failure(s); e.g., two or more hydraulic systems, flight control systems, etc.

c. Isolation of Systems, Components, and Elements so that the failure of one does not cause the failure of another. Isolation is also termed independence.

d. Proven Reliability so that multiple, independent failures are unlikely to occur during the same flight.

e. Failure Warning or Indication to provide detection.

f. Flightcrew Procedures for use after failure detection, to enable continued safe flight and landing by specifying crew corrective action.

g. Checkability: the capability to check a component's condition.

h. Designed Failure Effect Limits, including the capability to sustain damage, to limit the safety impact or effects of a failure.

i. Designed Failure Path to control and direct the effects of a failure in a way that limits its safety impact.

j. Margins or Factors of Safety to allow for any undefined or unforeseeable adverse conditions.

k. Error-Tolerance that considers adverse effects of foreseeable errors during the airplane's design, test, manufacture, operation, and maintenance.

APPENDIX 3. SUITABLE EN ROUTE ALTERNATE AIRPORTS

1. GENERAL.

a. One of the distinguishing features of two-engine extended range operations is the concept of a suitable en route alternate airport being available to which an airplane can divert after a single failure or failure combinations which require a diversion. Whereas most two-engine airplanes operate in an environment where there is usually a choice of diversion airports available, the extended range airplane may have only one alternate within a range dictated by the endurance of a particular airframe system (e.g., cargo fire suppressant), or by the approved maximum diversion time for that route.

b. It is, therefore, important that any airport designated as an en route alternate has the capabilities, services, and facilities to safely support that particular airplane, and that the weather conditions at the time of arrival provide a high assurance that adequate visual references are available upon arrival at decision height (DH) or minimum descent altitude (MDA), and that the surface wind conditions and corresponding runway surface conditions are within acceptable limits to permit the approach and landing to be safely completed with an engine and/or systems inoperative.

2. ADEQUATE AIRPORT. As with all other operations, an operator desiring any route approval should show that it is able to satisfactorily conduct scheduled operations between each required airport other than that route or route segment. Operators should show that the facilities and services specified in FAR Section 121.97 through 121.107 for domestic and flag air carriers (FAR Sections 121.113 through 121.127 for supplemental air carriers and commercial operators) are available and adequate for the proposed operation. For the purpose of this advisory circular, in addition to meeting Part 121 requirements of the FAR, those airports which meet the provisions of Part 139 and those foreign airports which are determined to be equivalent to the provisions of subparts D and E of FAR Part 139 for that particular airplane are considered to be adequate airports.

3. SUITABLE AIRPORT. For an airport to be suitable for the purpose of this advisory circular, it should have the capabilities, services, and facilities necessary to designate it as an adequate airport, and have weather and field conditions at the time of the particular operation which provide a high assurance that an approach and landing can be safely completed with an engine and/or systems inoperative in the event that a diversion to the en route alternate becomes necessary. Due to the natural variability of weather conditions with time as well as the

need to determine the suitability of a particular en route airport prior to departure, the en route alternate weather minima for dispatch purposes are generally higher than the weather minima necessary to initiate an instrument approach. This is necessary to assure that the instrument approach can be conducted safely if the flight has to divert to the alternate airport. Additionally, since the visual reference necessary to safely complete an approach and landing is determined, among other things, by the accuracy with which the airplane can be controlled along the approach path by reference to instruments and the accuracy of the ground-based instrument aids, as well as the tasks the pilot is required to accomplish to maneuver the airplane so as to complete the landing, the weather minima for nonprecision approaches are generally higher than for precision approaches.

4. STANDARD EN ROUTE ALTERNATE AIRPORT WEATHER MINIMA. The following are established for flight planning and dispatch purposes with two-engine airplanes in extended range operations. These weather minima recognize the benefits of precision approaches, as well as the increased assurance of safely completing an instrument approach at airports which are equipped with precision approaches to at least two separate runways, (two separate landing surfaces). A particular airport may be considered to be a suitable airport for flight planning and dispatch purposes for extended range operations if it meets the criteria of Paragraph 3 of this Appendix and has one of the following combinations of instrument approach capabilities and en route alternate airport weather minima:

a. A Single Precision Approach:

Ceiling of 600 feet and a visibility of 2 statute miles or a ceiling of 400 feet and a visibility of 1 statute mile above the lowest authorized landing minima; whichever is higher.

b. Two or More Separate Precision Approach Equipped Runways:

Ceiling of 400 feet and a visibility of 1 statute miles or a ceiling of 200 feet and a visibility of 1/2 statute mile above the lowest authorized landing minima; whichever is higher.

c. Non-precision approach(es):
Ceiling of 800 feet and a visibility of 2 statute miles or a ceiling of 400 feet and a visibility of 1 statute mile above the lowest authorized landing minima; whichever is higher.

5. LOWER THAN STANDARD EN ROUTE ALTERNATE AIRPORT WEATHER MINIMA. Lower than standard en route alternate airport weather minima may be considered for approval for certain operators on a case-by-case basis by the Director, Flight Standards Service, at suitably equipped airports for certain airplanes which have the certificated capability to safely conduct Category II and/or Category III approach and landing operations after encountering any failure

condition in the airframe and/or propulsion systems which would result in a diversion to an en route alternate airport. Subsequent failures during the diversion, which would result in the loss of the capability to safely conduct and complete Category II and/or Category III approach and landing operations, should be shown to be improbable. The certificated capability of the airplane should be evaluated considering the approved maximum diversion time. Lower than standard en route alternate weather minima may be considered at suitably equipped airports, if appropriate, for those airplanes which have these approved capabilities considering the established maximum diversion time.

6. EN ROUTE ALTERNATE SUITABILITY IN FLIGHT. The suitability of an en route alternate airport for an airplane which encounters a situation inflight which necessitates a diversion, including the provisions of FAR Section 121.565, while en route on an extended range operation is based on a determination that the airport is still suitable for the circumstances, and the weather and field conditions at that airport will permit an instrument approach to be initiated and a landing completed.

APPENDIX 4. 75, 120, and 180 MIN. ETOPS MAINTENANCE REQUIREMENTS

1. GENERAL. The maintenance program for airplanes used in 75-, 120-, and 180-minute ETOPS should contain the standards, guidance, and direction necessary to support the intended operations. Maintenance personnel involved in affecting this program should be made aware of the special nature of ETOPS and have the knowledge, skills and ability to accomplish the requirements of the program.

a. ETOPS Maintenance Program.

(1) Airplane Suitability. The airframe-engine combination being submitted for ETOPS consideration will be reviewed by the FAA, Propulsion System Reliability Assessment Board (PSRAB) and the responsible type certificate holding office. The FAA will review data accrued by the world fleet and the operator from operation of ETOPS candidate airplanes to help establish the operator's capability to conduct ETOPS operations. This candidate airplane should meet the requirements of Paragraph 9 of this advisory circular. The FAA will review data on the airframe-engine combination and identify any conditions that exist which could prevent safe operation.

NOTE: The candidate airplane for a 75-minute diversion time is not required to have achieved a predetermined number of hours or in-flight shutdown rate for this assessment.

(2) Maintenance Program. The basic maintenance program for the airplane being considered for ETOPS is the continuous airworthiness maintenance program currently approved for that operator, for the make and model airframe-engine combination. This program should be reviewed by the PMI to ensure that it provides an adequate basis for development of a supplemental ETOPS maintenance program. ETOPS maintenance requirements will be expressed in, and approved as, supplemental requirements. This should include maintenance procedures to preclude identical action being applied to multiple similar elements in any ETOP critical system (e.g., fuel control change on both engines). This relates to common cause concerns identified in Appendix 1, Paragraph 2.(d).

(i) ETOPS related tasks should be identified on the operator's routine work forms and related instructions.

(ii) ETOPS related procedures, such as involvement of centralized maintenance control, should be clearly defined in the operators program.

(iii) An ETOPS service check should be developed to verify that the status of the airplane and certain critical items are acceptable. This check should be accomplished and signed off by an ETOPS qualified maintenance person immediately prior to an ETOPS flight.

NOTE: The service check may not be required for the return leg of a 75-minute ETOPS flight in a benign area of operation (defined in Appendix 5).

(iv) Log books should be reviewed and documented as appropriate to ensure proper MEL procedures, deferred items, maintenance checks and that system verification procedures have been properly performed.

(3) ETOPS Manual. The operator should develop a manual for use by personnel involved in ETOPS. This manual need not be inclusive but should at least reference the maintenance programs and other requirements described by this advisory circular, and clearly indicate where they are located in the operator's manual system. All ETOPS requirements, including supportive programs, procedures, duties, and responsibilities, should be identified and subject to revision control. This manual should be submitted to the certificate-holding office 60 days before implementation of ETOPS flights.

(4) Oil Consumption Program. The operator's oil consumption program should reflect the manufacturer's recommendations and be sensitive to oil consumption trends. It should consider the amount of oil added at the departing ETOPS stations with reference to the running average consumption; i.e., the monitoring must be continuous up to, and including, oil added at the ETOPS departure station. If oil analysis is meaningful to this make and model, it should be included in the program. If the APU is required for ETOPS operation, it should be added to the oil consumption program.

(5) Engine Condition Monitoring. This program should describe the parameters to be monitored, method of data collection and corrective action process. The program should reflect manufacturer's instructions and industry practice. This monitoring will be used to detect deterioration at an early stage to allow for corrective action before safe operation is effected. The program should ensure that engine limit margins are maintained so that a prolonged single-engine diversion may be conducted without exceeding approved engine limits (i.e., rotor speeds, exhaust gas temperatures) at all approved power levels and expected environmental conditions. Engine margins preserved through this program should account for the effects of additional engine loading demands (e.g., anti-ice, electrical, etc.) which may be required during the single-engine flight phase associated with the diversion. (See Paragraph 8b(2)(iv).)

(6) Resolution of Airplane Discrepancies. The operator should develop a verification program or procedures should be established to ensure corrective action following an engine shutdown, primary system failure, adverse trends or any prescribed events which require verification flight or other action and establish means to assure their accomplishment. A clear description of who must initiate verification actions and the section or group responsible for the determination of what action is necessary should be identified in the program. Primary systems, like APU, or conditions requiring verification actions should be described in the operators ETOPS maintenance manual.

(7) Reliability Program. An ETOPS reliability program should be developed or the existing reliability program supplemented. This program should be designed with early identification and prevention of ETOPS related problems as the primary goal. The program should be event-orientated and incorporate reporting procedures for significant events detrimental to ETOPS flights. This information should be readily available for use by the operator and FAA to help establish that the reliability level is adequate, and to assess the operator's competence and capability to safely continue ETOPS. The FAA certificate-holding district office should be notified within 72 hours of events reportable through this program.

(i) Besides the items required to be reported by Section 21.3 and 121.703 of the FARs, the following items should also be included:

(A) In-flight shutdowns.

(B) Diversion or turnback.

(C) Uncommanded power changes or surges.

(D) Inability to control the engine or obtain desired power.

(E) Problems with systems critical to ETOPS.

(F) Any other event detrimental to ETOPS.

(ii) The report should identify the following.

(A) Airplane identification (type and N-Number).

(B) Engine identification (make and serial number).

(C) Total time, cycles, and time since last shop visit.

(D) For systems, time since overhaul or last inspection of the discrepant unit.

(E) Phase of flight.

(F) Corrective action.

(8) Propulsion System Monitoring. Firm criteria should be established as to what action is to be taken when adverse trends in propulsion system conditions are detected. When the propulsion system IFSD (computed on a 12-month rolling average) exceeds .05/1000 engine hours for a 120-minute operation, or exceeds .03/1000 engine hours for a 180-minute operation, an immediate evaluation should be accomplished by the operator and certificate-holding district office with consultation of the PSRAB. A report of problems identified and corrective actions taken will be forwarded to the Director, Flight Standards Service. With advice of the PSRAB, additional corrective action or operational restriction may be recommended.

(9) Maintenance Training. The maintenance training program should focus on the special nature of ETOPS. This program should be included in the normal maintenance training program. The goal of this program is to ensure that all personnel involved in ETOPS are provided the necessary training so that the ETOPS programs are properly accomplished and to emphasize the special nature of ETOPS maintenance requirements. Qualified maintenance personnel are those that have completed the operator's extended range training program and have satisfactorily performed extended range tasks under the direct supervision of a FAA certificated maintenance person; who has had previous experience with maintaining the particular make and model aircraft being utilized under the operator's maintenance program.

(10) ETOPS Parts Control. The operator should develop a parts control program that ensures the proper parts and configuration are maintained for ETOPS. The program includes verification that parts placed on ETOPS airplanes during parts borrowing or pooling arrangements, as well as those parts used after repair or overhaul, maintain the necessary ETOPS configuration for that airplane.

APPENDIX 5. ETOPS OPERATIONAL PROGRAM CRITERIA

1. GENERAL. Paragraphs 10.a. through 10.h. of this AC detail the criteria for operational approval of extended range operations with a maximum diversion time of 120 minutes to an en route alternate (at approved single-engine inoperative cruise speed). This appendix serves the function of differentiating the criteria for approval of operations less than 120 minutes (75 minutes) and beyond 120 minutes (180 minutes). For approval of 75-minute operations, not all of the requirements of the basic AC need necessarily be met. For approval of 180 minute operations, all of the requirements of the basic AC must be met along with the requirements identified in the Appendix as necessary for 180-minute operations.

2. 75-MINUTE OPERATION. Deviations to Section 121.161 of the FAR were granted to conduct 75-minute ETOPS in the Western Atlantic Caribbean Sea in 1977. Due to the benign nature of the area of operation, the criteria for type design, maintenance, and operational programs were less stringent than that contained in AC 120-42. Experience has shown that operations have been conducted safely and successfully since that time. In 1987, deviation to FAR Section 121.161 was granted to conduct 75-minute ETOPS in the North Atlantic. Due to more demanding area of operations, maintenance and operational programs which met the criteria of AC 120-42 were applied. The Type Design ETOP approval criteria were not required; however, the airframe-engine combination was reviewed prior to approval. Operations have been conducted successfully. The criteria detailed below are the basis for evaluating different areas of operation and requirement for approving 75-minute operation.

a. Benign Area of Operation. To be defined as a benign area of operation, the following considerations should apply:

(1) Numerous adequate airports.

(2) A high level of reliability and availability are required of communications, navigation, and ATC services and facilities.

(3) Prevailing weather conditions are stable and generally do not approach extremes in temperature, wind, ceiling, and visibility.

b. Criteria for Deviation to Operate in a Benign Area of Operation.

(1) Type Design. The airframe-engine combination should be reviewed to determine if there are any factors which would effect safe conduct of operations. Type design ETOP approval criteria are not necessarily required.

(2) Maintenance programs should follow the guidance in Appendix 4 for 75-minute programs.

(3) Operational Programs.

(i) Minimum Equipment List. Provision of the FAA MMEL, excluding "Extended Range" provisos, apply.

(ii) Dispatch limitations. Flight should be operated at a weight that permits the flight, at approved one-engine inoperative cruise speed and power setting, to maintain flight altitude at or above the Minimum En route Altitude.

c. Demanding Area of Operation. A demanding area of operations for the purpose of 75-minute approval has one or more of the following characteristics:

(1) Weather. Prevailing weather conditions can approach extremes in winds, temperature, ceiling, and visibility for protracted periods of time.

(2) Alternates. Adequate airports are not numerous.

(3) Due to remote or overwater area, a high level of reliability and availability of communications, navigation, and ATC facilities services may not exist.

d. Criteria for Deviation to Operate in a Demanding Area of Operation.

(1) Type Design. The airframe-engine combination should be reviewed to determine any factors which could effect safe operations in the demanding area of operations. Type design ETOP approval criteria are not necessarily required.

(2) Maintenance programs should be instituted which follow the guidance in Appendix 4 for 120-minute operation.

(3) Operation programs should be instituted which follow the guidance contained in this AC for 120-minute programs.

3. 180-MINUTE OPERATION. Each operator requesting approval to conduct extended range operations beyond 120 minutes should have approximately 12 consecutive months of operational inservice experience with the specified ETOPs configured airframe-engine combination in the conduct of 120-minute operations. The substitution of inservice experience which is equivalent to the actual conduct of 120 operators will be established by the Director, Flight Standards Service, on a case-by-case basis. Prior to approval, the operator's capability to conduct operations and implement effective ETOP programs in accordance with the criteria detailed in Paragraph 10 of this advisory circular will be

examined. Only operators who have demonstrated capability to conduct a 120-minute program successfully will be considered for approval beyond 120 minutes. These operators should also demonstrate additional capabilities discussed in this paragraph. Approval will be given on a case-by-case basis for an increase to their area of operation beyond 120 minutes. The area of operation will be defined by a maximum diversion time of 180 minutes to an adequate airport at approved one-engine inoperative cruise speed (under standard conditions in still air). The dispatch limitation will be a maximum diversion time of 180 minutes to a suitable airport at approved single-engine inoperative speed (under standard conditions in still air).

a. Dispatch Considerations.

(1) MEL. The MEL should reflect adequate levels of primary system redundancy to support 180-minute (still air) operations. The systems listed in Paragraph 10.d.(2)(i) through (xv) should be considered.

(2) Weather. An operator should substantiate that the weather information system which it utilizes can be relied upon to forecast terminal and en route weather with a reasonable degree of accuracy and reliability in the proposed area of operation. Such factors as staffing, dispatcher training, sources of weather reports and forecasts, and when possible, a record of forecast reliability should be evaluated.

(3) Fuel. The critical fuel scenario should also consider fuel required for all engine operations at 10,000 feet or above 10,000 feet if the airplane is equipped with sufficient supplemental oxygen in accordance with FAR Section 121.329.

(4) Operational Control Practices and Procedures. During the course of the flight, the flightcrew should be informed of any significant changes in conditions at designated en route alternates. Prior to a 180-minute ETOP flight proceeding beyond the extended range entry point, the forecast weather for the time periods established in paragraph 10.d(5)(iii), landing distances, and airport services and facilities at designated en route alternates should be evaluated. If any conditions are identified (such as weather forecast below landing minima) which would preclude safe approach and landing, the pilot should be notified and an acceptable alternate(s) selected where safe approach and landing can be made. The maximum diversion time to the newly selected alternate(s) should not exceed 180 minutes at the approved single-engine inoperative cruise speeds (under standard conditions in still air).

(5) Flight Planning. Operators should provide for compliance with FAR Section 121.565. The effects of wind and temperature at single-engine inoperative cruise altitude should be accounted for. In addition, the operator's program should provide

flightcrews with information on suitable airports appropriate to the route to be flown which are not forecast to meet Appendix 3 en route alternate weather minima. Airport facility information, and other appropriate planning data concerning these airports should be provided to flightcrews for use in complying with FAR Section 121.565 when executing a diversion.

b. Crew Training and Evaluation.

(1) If standby sources of electrical power significantly degrade cockpit instrumentation to the pilots, then approved training which simulates approach with the standby generator as the sole power source should be conducted during initial and recurrent training.

(2) Contingency Procedures. Flightcrews should be provided detailed initial and recurrent training which emphasizes established contingency procedures for each area of operation intended to be used.

(3) Diversion Decisionmaking. Special initial and recurrent training to prepare flightcrews to evaluate probable propulsion and airframe systems failures should be conducted. The goal of this training should be to establish crew competency in dealing with the most probable operating contingencies.

c. Equipment.

(1) VHF/Satellite Data Link. Operators should consider enhancements to their operational control system as soon as they become feasible.

(2) Automated System Monitoring. Automated airplane system status monitoring should be provided to enhance the flightcrew's ability to make timely diversion decisions.

4. VALIDATION FLIGHT OR FLIGHTS. The operator should demonstrate by means of an FAA witnessed validation flight that it has the capability to safely conduct 180-minute operations with the specified airframe-engine combination. The guidance for validation flights contained in Paragraph 10.h. of this AC should be followed.

U.S. Department
of Transportation

**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

BULK MAIL
POSTAGE & FEES PAID
FEDERAL AVIATION
ADMINISTRATION
PERMIT NO. G-44

RETURN POSTAGE GUARANTEED

Official Business
Penalty for Private Use $300